**Herbicide injury evaluations in *Camelina sativa*.** Nicholas George, Seth Watkins, Brad Hanson, Joy Hollingsworth and Steve Kaffka (Department of Plant Sciences University of California, Davis. Davis, CA 95616-8515) Gerardo Banuelos and Steve Wright (University of California Cooperative Extension, 4437 S. Laspina St. Ste. B Tulare, CA 93274-9537). *Camelina sativa* (camelina) is an oilseed with potential as a winter crop in California. Early stage evaluation of camelina in California has found the species is winter hardy, has good yield potential, and is tolerant of relatively limited soil moisture and low nutrient conditions. Lack of effective weed control is likely to be a factor that would limit the adoption this crop in the state. There is very little published research on the herbicide tolerance of camelina and few herbicides labeled for the species. A field study was established in two locations in California to examine the impact of different pre- and post-emergent herbicides on three varieties of camelina.

Sites were established at the University of California West Side Research and Extension Center (Lat 36.34 Long -120.11) and the University of California Davis Research Station (Lat 38.54 Long -121.78). Replicate soil samples from the top 20 cm of each field were bulked and analyzed by A & L Western Agricultural Lab (1311 Woodland Ave, Modesto, CA 95351). Ammonium sulfate was applied pre-plant at a rate of 110 kg/ha at the West Side site and 80 kg/ha at the Davis site. At the Davis site an additional top-dress of ammonium sulfate was applied at a rate of 60 kg/ha in spring.

Table. Soil analysis data.

| | OM % | N (ppm) | P (ppm) | K (ppm) | pH | Soil type |
|---|---|---|---|---|---|---|
| Davis | 2 | 31 | 15 | 218 | 6.9 | Loam |
| West Side | 1.6 | 33 | 9 | 359 | 7.7 | Clay |

The sites were planted with a 6-row Wintersteiger grain drill at a seeding rate of approximately 6 kg/ha. Three camelina varieties developed by Global Clean Energy (GCE) Holdings Inc. were used: CS11, CS14 and SO-50. The varieties were reported by GCE to have differing genetic backgrounds. The West Side site was planted on October 28th 2013 and the Davis site was planted on November 15th 2013. Individual plots were approximately 1.8 m wide and 8.5 m long. The West Side site received 75 mm of rainfall and 177 mm of sprinkler irrigation. The Davis site received 219 mm of rainfall and 100 mm of sprinkler irrigation.

Sixteen herbicide treatments (six pre-plant incorporated herbicides, nine post-emergent herbicides and one untreated control) were used in combination with all three camelina varieties to give 48 treatments in total. Plots were arranged in a randomized complete block design with three replicates. Davis was treated on November 13th, 2013 and January 27th, 2014 and West Side on October 28th and December 9th, 2013. The pre-plant treatments were mechanically incorporated prior to planting. Camelina plants were at the early rosette stage when post-emergence treatments were applied. Visual ratings of crop injury were taken five times throughout the growing season. At West Side ratings were taken on Dec 9th and Dec 13th 2013, and Jan 6th, Jan 13th and Feb 21st 2014. At Davis, ratings were taken on Jan 15th, Feb 4th, Feb 10th, Feb 24th and Mar 21st 2014.

Table. Herbicide treatments and rates evaluated in two camelina crop safety trials conducted during the 2013-14 growth season near Davis and Fresno CA.

| Treatment details | Treatment | Treatment details | Treatment |
|---|---|---|---|
| Pre-plant herbicides | Matrix (2oz) | Post-plant herbicides | Poast (2.25 pt) |
| | Prowl (4pt) | | FusiladeDX (10floz) |
| | Treflan (3 pts) | | SelectMax (12 fl oz) |
| | Dual Magnum (1.67pt) | | AxialXL (16fl oz) |

| | | |
|---|---|---|
| | Outlook (14 floz) | Puma (10.6fl oz) |
| | FacetL (2pt) | Transline (1pt) |
| | | Buctril (0.75pt) |
| | | 2,4-D amine (1pt) |
| | | MCPA amine(1pt) |

Fusilade, Transline, Buctril, 24D, and MCPA treatments included a nonionic surfactant (Induce) at 0.25% v/v. The FacetL formulation of quinclorac was used at the West Side location but Drive75 was used at Davis at an equivalent rate.

All data analyses were conducted using the program R (R Core Team. 2013. R: A Language and Environment for Statistical Computing). A Bartlett test and visual examination of data found significant variance heterogeneity in the extent of crop injury among herbicide treatments (Bartlett's K-squared = 85.8, df = 15, p-value <0.001) therefore a standard ANOVA was not appropriate for analyzing the data. Instead, an ANOVA was conducted based on a linear mixed model. This analysis found herbicide treatment had a significant effect on crop injury. The analysis also found that crop injury did not vary between different rating times or crop varieties.

Table. Analysis of Variance of type 3 with Satterthwaite approximation for degrees of freedom

| | Sum Sq | Mean Sq | NumDF | DenDF | F.value | Pr(>F) |
|---|---|---|---|---|---|---|
| Herbicide | 401863.0 | 25116.5 | 16.0 | 188.0 | 84.0 | <0.01 |
| Site | 7173.0 | 7173.0 | 1.0 | 4.0 | 44.1 | <0.01 |
| Variety | 310.0 | 155.2 | 2.0 | 188.0 | 1.0 | 0.39 |
| Herbicide x Site | 23191.0 | 1546.1 | 15.0 | 188.0 | 9.5 | <0.01 |
| Herbicide x Variety | 4380.0 | 146.0 | 30.0 | 188.0 | 0.9 | 0.62 |
| Site x Variety | 6.0 | 3.1 | 2.0 | 188.0 | 0.0 | 0.98 |
| Herbicide x Site x Variety | 2576.0 | 85.9 | 30.0 | 188.0 | 0.5 | 0.98 |

Pair-wise comparisons of herbicide treatments based on a Kruskal analysis, that averaged across all varieties and rating times, found that crop injury did not differ significantly from the control for eleven of the herbicide treatments. These products would therefore be candidates for further testing and possible consideration for registration in camelina.

Table. Kruskal tests for crop injury differences between herbicide treatments and controls.

| Herbicide Treatment | Different from control (P=0.05) |
|---|---|
| Axial XL | FALSE |
| Buctril | FALSE |
| Dual Magnum | FALSE |
| FacetL | FALSE |
| Fusilade DX | FALSE |
| Poast | FALSE |
| Prowl | FALSE |
| Puma | FALSE |
| Select Max | FALSE |
| Transline | FALSE |
| Treflan | FALSE |
| | |
| 2,4-D amine | TRUE |
| Matrix | TRUE |
| MCPA amine | TRUE |
| Outlook | TRUE |

The "false" outcome in this hypothesis test indicates that crop injury ratings from this herbicide treatment were not different from the untreated control.

The following figure summarizes the crop injury ratings for the different herbicide treatments. The level of injury in the non-treated control indicates environmental or biotic factors that have contributed to observations of injury not due solely to the herbicide treatments.

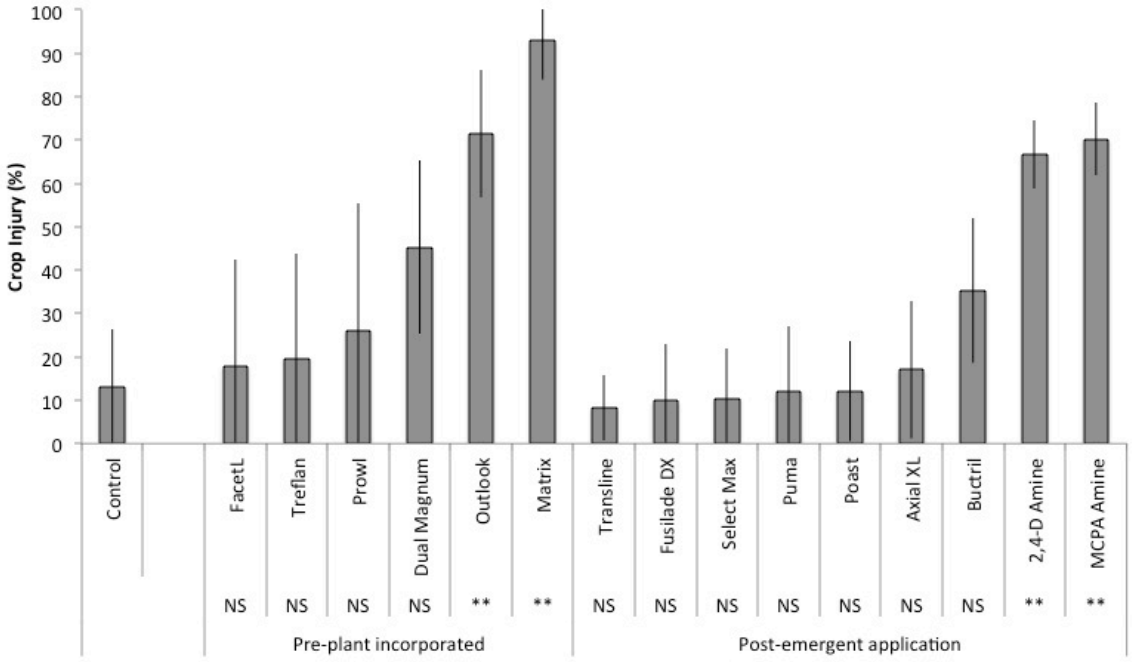


Figure. A summary of crop injury data, averaged over several rating dates, two California locations, and three camelina varieties during the 2014 growing season. Kruskal test: NS – injury rate not significantly different from untreated control & ** - injury rate significantly greater than untreated control ($p$<0.05)